METHOD OF REPRODUCING A DIE AND PROPERTY CHECK METHOD OF THE SAME

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a method of reproducing a die that is suitably used for resin-molding of a lens sheet, and a property check method of the die.

Description of the Related Art

A method of reproducing another die from a preceding or original die with use of resin has been executed. For example, Japanese Patent Application Laid-Open No. H10-323839 discloses the following method. Namely, into a metallic die (master) having provided thereon a reverse concavities/convexities pattern of a molded article is injected a first thermosetting resin, which is then hardened. Thereafter, mold-releasing of it is performed to thereby obtain a resin-made die (mother). Then a second thermosetting resin is injected into that resin-made die to thereby obtain a second thermosetting resin layer. Onto this layer is laminated a metal or ceramic-made plate material to thereby obtain a primary hardening die. Further, from that resin-made die is released the primary hardening die, which is then secondary-hardened. Thereby, there is manufactured a molding die (stamper).

Also, Japanese Patent Application Laid-Open No. H05-156484 discloses the following method. Using a hot-press molding method, a metal-made master is transferred to thereby

mold a mother die (mother) for use for electroforming that consists of an electrically conductive base material. Then, electroforming is performed. Then from a metal layer that has been electro-deposited on a main surface of the mother die there is obtained a metal die (stamper) for molding a Fresnel lens. Then, this metal die and transparent thermosetting resin are superposed one upon the other to thereby manufacture a Fresnel lens through the use of the hot-press molding method.

Further, Japanese Patent No. 2736561 discloses a resin die obtained as follows. Namely, that die is obtained by hardening an epoxy resin composition for use for resin die having the following three materials. The first one is (a): epoxy resin. The second one is (b) acid anhydride hardening agent having a chemical equivalent of 0. 2 to 0. 7 with respect to the epoxy resin. And the third one is thixotropic applicator that occupies 0. 5 to 5 wt. % based on the total weight.

However, in case using resin as a die, the surface of the die is likely to be scratched or flawed due to the troubles, etc. at the time of manufacture. Also, in case using a UV hardening resin as the resin for use of molding, the resulting die is likely to be corroded due to monomer, etc. in the UV resin. Accordingly, there was the problem that the service life of one piece of die was short.

On the other hand, in case cutting and machining a metal plate with use of an ultra-hard cutting tool such as a diamond into a master die that is used for manufacture of a lens sheet, because the die per se is large in size (usually from 40 to 80

inches), it is not easy to manufacture a plurality of pieces of master dies having the same property by reason of the wear of the cutting tool. Accordingly, in order to mass produce lens sheets of the same property, it is necessary to reproduce a mother die and stamper of long life in large number from one piece of master die. Also, in order to guarantee the property of a reproduced stamper, it is also needed to check within a short period of time that the property of the master die has no problem.

SUMMARY OF THE INVENTION

Thereupon, the present invention has an object to provide a method of reproducing a die that enables reproducing dies of a long service life in large number and a property check method of a die that enables determining within a short period of time whether the property of the master die is good.

The present invention will hereafter be explained. In the first embodiment of the present invention, the above-described problem is solved by the method of reproducing a die, that comprises an electroforming process that manufactures a stamper equipped with a reverse concavities/convexities pattern, through electroforming, from a mother die equipped with a normal concavities/convexities pattern on its surface. Here, the "mother die" means a die that has been formed thereon the surface of the normal concavities/convexities pattern of the product. Also, the "stamper" means a die that has been formed thereon the reverse concavities/convexities pattern of the product by the use of the mother die and that is used for

resin-molding of the product.

According to this aspect of the invention, since electroforming process is used for reproducing the die, the normal concavities/convexities pattern of the product that is formed on the surface of the mother die can be transferred with a high precision to the stamper side.

In the second embodiment of the present invention, the above-described problems are solved by the method of reproducing a die that comprises the first electroforming process that manufactures a mother die equipped with a normal concavities/convexities pattern, through the electroforming, from a master die formed with a reverse concavities/convexities pattern on its surface; and the second electroforming process that further manufactures a stamper die equipped with a reverse concavities/convexities pattern, through electroforming, from the mother die. Here, the "master die" means the one that is a metal original plate whose surface has been formed thereon a reverse concavities/convexities configuration of the product. Also, in this embodiment, the "mother die" is the one that has transferred thereto the product reverse concavities/convexities pattern of the master die and that thereby has been formed on its surface the normal concavities/convexities configuration of the product.

According to this aspect of the invention, the first electroforming or second electroforming process is repeatedly performed suitably, whereby a desired number of the mother dies and stamper dies can be obtained with a high precision.

Also, in the first embodiment, it may be arranged that the method has, in advance of the electroforming process, a plating process that forms a plated layer on the surface of the normal concavities/convexities pattern formed on the mother die, or in the second enbodiment, it may be arranged that the method has, in advance of the first electroforming process, a plating process that forms a plated layer on the surface of the reverse concavities/convexities pattern formed on the master die.

If the construction is made like that, it is possible to protect the mirror surface state of the original-plate die surface immediately after the cutting of the original plate and thereby prevent the occurrence of any causes of the stains that occur in the surface of the product due to the fine defects, dirties, etc.

Also, in the first embodiment, it may also be arranged that the method has the exfoliation layer forming process that after the plating process in advance of the first electroforming process forms an organic exfoliation layer on the surface of the plated layer of the mother die, or, in the second embodiment, has the first exfoliation layer forming process that after the plating process in advance of the first electroforming process forms an organic exfoliation layer on the surface of the plated layer of the master die; and the second exfoliation layer forming process that in advance of the second electroforming process forms an organic exfoliation layer on the normal concavities/convexities pattern surface of the mother die

If the construction is made like that, the exfoliation

between the master die and the mother die, and the mother die and the stamper, are smoothly carried out, whereby it is possible to avoid the occurrence of an accident that would cause damages to the die.

Further, in each of these aspects of the present invention, it may be arranged to construct the invention in the form wherein the stamper is used for molding a lens sheet. Here, the "lens sheet" means a sheet-like member having formed on its surface a predetermined configuration of concavities/convexities, which sheet-like member is the one that through transmitting or reflecting a light condenses or disperses the light in a predetermined direction. Examples of the lens sheet include the Fresnel lens sheet described in the above-described Japanese Patent Application Laid-Open No. 5-156784 and the lenticular lens sheet, fly-eye lens sheet, linear Fresnel lens sheet, etc. that have the dies for manufacturing them introduced in Fig. 5.

If the construction is made like that, the above-described aspects of the invention can be applied to reproducing a die that is used for molding a lens sheet.

The third aspect of the present invention can be constructed as the method of reproducing a die that has a deposition film forming process that forms a deposition film on the surface of a concavities/convexities pattern of the product; and has an electroforming process that manufactures a stamper equipped with a reverse concavities/convexities pattern, through the electroforming, on the

concavities/convexities pattern surface of the product having formed thereon the deposition film.

According to this aspect, as the mother die there is used the product that has already had its property confirmed as the lens sheet in terms of whether it is good. In addition, the electroforming process that needs a long time has only to be executed once. Therefore, it is possible to reproduce the same property of die within a short period of time.

In the above-described aspect, it may be arranged to construct the method in the form wherein the product is a lens sheet.

If the construction is made like that, the above-described aspect of the invention can be applied to reproducing a die that is used for molding a lens sheet.

In another one aspect of the present invention, the above-described problems are solved by providing a property check method of a master die, in a reproduction process of a die that includes the first electroforming process that manufactures a mother die equipped with a normal concavities/convexities pattern, through the electroforming, from a master die having formed on its surface a reverse concavities/convexities pattern; and the second electroforming process that further manufactures a stamper equipped with a reverse concavities/convexities pattern, through the electroforming, from the mother die, comprising a plating process that plates the surface of the reverse concavities/convexities pattern of the master die; a molding process that directly molds a product by the use of the

plated master die; and a property check process that performs property check of the directly molded product.

According to this aspect, whereas conventionally the property of the master die was checked in terms of whether it is good, by means of the product that was manufactured using the stamper that is manufactured through the twice executed electroforming process taking a long time and further performing resin molding from that stamper, the method of the present invention obtains the product by directly resin molding from the master die. Therefore, it is possible to determine within a short period of time whether the property of the master die is good.

In the above-described aspect, it may be arranged to construct the method in the form wherein the product is a lens sheet.

If the construction is made like that, the above-described aspect of the invention can be applied to determining whether the property of the master die used for molding the lens sheet is good.

The above-described functions and advantages of the present invention will become apparent from the embodiments that will be explained next.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a view illustrating a first embodiment of the present invention;

Fig. 2 is a view illustrating a second embodiment of the

present invention;

Fig. 3 is a view illustrating a third embodiment of the present invention;

Fig. 4 is a view illustrating a checking method within a short period of time whether the property of the master die is good; and

Figs. 5A, 5B, and 5C are views respectively illustrating the configurations of stampers for use for a lenticular lens sheet, fly-eye lens sheet, and linear Fresnel lens sheet.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will hereafter be explained on the basis of the embodiments illustrated in the appended drawings.

(First embodiment)

Fig. 1 shows process views of a method of reproducing a die according to the first embodiment of the present invention. Here, first, in the surface of a rectangular or square metal original plate the one-side length of that is from 1 to 2 m and the thickness of that is from 15 to 20 mm or so there is formed by cutting a normal concavities/convexities configuration of a lens sheet. Thereby, a mother die is manufactured. From the viewpoint of its being easy to fabricate, of its surface being unlikely to be corroded, etc., non-ferric metal such as aluminum, copper, brass, etc. are suitably used as the material of the metal original plate. The cutting operation is performed as follows. A metal original plate is set on a large-sized lathe. While this original plate is being rotated, the normal

concavities/convexities pattern of the lens sheet goes on being engraved into the surface of the original plate by the use of an ultrahard tool such as a diamond cutting tool. In this cutting operation, in order to prevent the wear of the cutting tool, cutting oil is used. The reason for this is as follows. In the surface of one piece of mother die it is necessary to form in large number the normal concavities/convexities pattern of the lens sheet the configuration of that is complicated. And time that is needed for performing the cutting operation is very long (usually, from one week to ten days). Therefore, when the tool has been worn, they have extreme difficulty in reproducing the configuration of high precision.

As for the mother die the cutting process of that has finished being executed, the cutting oil that has adhered on the surface thereof is completely removed through the execution of solvent degreasing, alkaline electrolysis degreasing, ultrasonic degreasing, etc. processs. Then, the mother die is made to undergo a plating process. In the plating process, with an aim to protect a mirror-surface state of the mother-die surface after cutting and improve the corrosion resistance, there are performed a luster nickel plating, nickel plating, chrome plating, etc.

As for the mother die the plating process of that has finished being performed, for the purpose of smoothing the exfoliation after electroforming process executed later, an organic system of exfoliation layer is formed on that surface. As the organic system of exfoliation layer, for example, the

"Nikka Nontack" (the registered trademark in Japan) produced by Nihon Kagaku Sangyo Co., Ltd. is commercially available.

Thereafter, the mother die is immersed in an electroforming bath, whereby electroforming goes on being performed until a plated film of nickel, etc. is formed on the surface thereof to a predetermined thickness (e.g. 20 mm or more). An approximately one week is needed for executing this electroforming process. The plated layer that has come to have a predetermined thicknesss is exfoliated from the mother die, and, according to the necessity, backing with respect thereto is performed with the use of a reinforcing plate. The resulting plated layer is repeatedly used as the stamper for resin molding of the products.

In the above-described first embodiment, the stamper is manufactured from the mother die through the execution of the electroforming process. Therefore, the concavities/convexities of the lens surface that have been formed in the surface of the mother die can be transferred with a high precision. Also, since the material property of the stamper is metal such as nickel, the stamper has the difficulty of being scratched or flawed compared with a resin-made die. Namely, there is no fear that it will be affected by the low-molecular components in the resin and thereby eroded. Also, the surface of the mother die immediately after the cutting thereof is protected by the plated layer, with the result that it is possible to maintain that surface in a mirror surface state. Also, since the organic system of exfoliation layer is formed, in the

exfoliation process after electroforming, frictional force or bonding force becomes unlikely to work. Resultantly, the die is prevented from having its surface damaged.

(Second embodiment)

Fig. 2 shows process views of the method of reproducing a die according to the second embodiment of the present invention. Here, first, in the surface of the metal original plate similar to that of the first embodiment, a reverse concavities/convexities configuration of a lens sheet is formed, whereby a master die is manufactured. The cutting operation and the cutting-oil-degreasing process are the same as in the case of the first embodiment. Thereafter, the master die is made to undergo the plating process. In the plating process, with an aim to protect the mirror-surface state of the mother-die surface after cutting and improve the corrosion resistance, there are performed a luster nickel plating, nickel plating, chrome plating, etc.

As for the master die the plating process of that has finished being performed, for the purpose of smoothing the exfoliation after the first electroforming process executed later, an organic system of exfoliation layer is formed on that surface as the first time. Thereafter, the master die is immersed in an electroforming bath, whereby electroforming goes on being performed until a plated film of nickel, etc. is formed on the surface thereof to a predetermined thickness (e.g. 20 mm or more). An approximately one week is needed for executing this electroforming process. The plated layer that has come to have

a predetermined thickness is exfoliated from the master die. This plated layer has had its surface formed with a normal concavities/convexities of a lens sheet and is called "a mother die".

The mother die that has been manufactured by the first electroforming process, in order to smooth the exfoliation after a second electroforming process performed ahead, a second-time organic system of exfoliation layer is formed on that surface.

Subsequently, the second electroforming process is executed based on that mother die, whereby electroforming is performed until a plated layer of nickel, etc. is formed on that surface to a predetermined thickness (e.g. 20 mm or more). An approximately one week is needed for executing this electroforming process as well. The plated layer that has come to have a predetermined thickness is exfoliated from the mother die. This plated layer has had its surface formed with a reverse concavities/convexities configuration of the lens sheet, and, according to the necessity, backing with respect thereto is performed with the use of a reinforcing plate. The resulting plated layer is repeatedly used as the stamper for resin molding of the products.

In the above-described second embodiment, manufacture of the mother die is made from the master die and manufacture of the stamper is made from that mother die. Therefore, the concavities/convexities of the lens surface that have been formed in the surface of the master die can be highly precisely transferred to the stamper. Also, through suitable repetition

of the first and the second electroforming, it is possible to manufacture from the same master die(i.e. the same property of lens surface) each of the mother die and the stamper in a number that is wanted. This can be made to contribute to mass-producing the lens sheets having the same property. Also, since the material property of the stamper is metal such as nickel, the stamper has the difficulty of being scratched or flawed compared with a resin-made die. Also, there is no fear that it will be affected by the low-molecular components in the resin and thereby eroded.

(Third embodiment)

Fig. 3 shows process views of the method of reproducing a die according to the third embodiment of the present invention. Here, a product (plastic lens) with regard to that it is already confirmed that the property as the lens sheet is excellent is used as an original die. The details of this are as follows.

First, nickel, nickel and chrome, ITO, or gold is deposited on the surface of the plastic lens to a thickness of 2000 to 3000 Å. Subsequently, on that deposited surface, a plated layer having a predetermined thickness (20 mm or more) is formed by electroforming. Then, the plated layer is peeled off. The thus-peeled-off plated layer has formed in its surface a reverse concavities/convexities configuration, and, according to the necessity, is backed using a reinforcing plate. As a result of this, this plated layer can be repeatedly used for resin-molding of the products as the stamper. In addition, since the property of the original die is already guaranteed, the plated

layer can be used as the stamper for resin-molding of the lens sheet of substantially the same property as that of it. Therefore, it can contribute to enhancing the mass-productivity.

(Fourth embodiment)

Fig. 4 shows views illustrating a method for determining within a short period of time whether the property of the master die is qualified. Here, the method is intended to obtain the lens sheet that is a product, using the mater die having undergone the plating process directly as a resin-molding die. The details of the resulting effect are as follows. Namely, as stated before, it takes about one week for completion of the once executed electroforming process. However, in order to finally confirm whether the property of the master die is good, it is necessary to cause light to transmit the lens sheet to thereby inspect the defects. Accordingly, according to the method of reproducing a die according to the first embodiment or third embodiment, at least one week is needed for confirming the property of the master die. Also, according to the method of reproducing a die according to the second embodiment wherein the electroforming process is repeatedly executed twice, at least two weeks are necessary for confirming the property of the master die. However, if obtaining the product by the use of the method illustrated in Fig. 4, because of passing no electroforming process, it is possible to confirm the property of the product within a very short period of time. Namely, it is possible to determine within such a short period of time whether the property of the master die is good. In this case, the master die can

of course be used for electroforming after its surface has sufficiently been cleaned.

The present invention is suitably used for reproducing the lens sheet dies. The lens sheets that are used in the largest number are thought to be Fresnel lens sheets. However, the method of the present invention, other than those lens sheets, is suitably used for reproducing, and checking the property, of dies such as lenticular lens sheets, fly-eye lens sheets, or linear Fresnel lens sheets. Regarding these lens sheets, Fig. 5A illustrates the configuration of a stamper for use for lenticular lens sheets; Fig. 5B illustrates that of a stamper for use for fly-eye lens sheets; and Fig. 5C illustrates that of a stamper for use for linear Fresnel lens sheets.

In each of the respective modes of the present invention, each of the master die and mother die that has passed through the electroforming process thereafter undergoes alkaline cleaning. Thereby, the plating solution is simultaneously neutralized while the exfoliation layer that had been formed before electroforming is being completely removed. Thereafter, newly, another new exfoliation layer is formed thereon, whereby this die is used in the electroforming process again.

The present invention is not limited to the above-described embodiments and permits suitable changes or alterations to be made without departing from the subject matter, or the idea, of the invention that is readable from the claims and the entire specification of it. The methods of reproducing, and the methods of determining, a die that result from such changes or alterations

are also included in the technical range of the present invention.

As has been explained above, if the method of reproducing a die has the electroforming process that manufactures a stamper having a reverse concavities/convexities pattern by electroforming process from a mother die having a normal concavities/convexities pattern on its surface, it is possible to transfer with a high precision the normal lens sheet concavities/convexities pattern formed in the mother die to the stamper side.

Also, if another method of reproducing a die has the first electroforming process that manufactures a mother die having a reverse concavities/convexities pattern by electroforming process from a master die having a normal concavities/convexities pattern on its surface and the second electroforming process that manufactures a stamper die having a reverse concavities/convexities pattern by electroforming process from the mother die, the repetition of that electroforming process enables obtaining each of the mother die and the stamper die in a wanted number while the high precision of the pattern is being maintained.

Also, if it is arranged that the method of the invention has the plating process that in advance of the electroforming process forms a plated layer on the surface of a normal concavities/convexities pattern formed in the mother die, or, has the plating process that in advance of the first electroforming process forms a plated layer on the surface of a reverse concavities/convexities pattern form in the master

die, it is possible to protect the mirror-surface state on the original-plate die surface immediately after cutting thereof by the use of the plated layer to thereby prevent the production of any causes of the stain in the lens surface.

Also, if it is arranged that the method of the invention has the exfoliation layer forming process that after the plating process in advance of the electroforming process forms an organic exfoliation layer on the surface of the plated layer of the mother die, or has the first exfoliation layer forming process that after the plating process in advance of the first electroforming process forms an organic exfoliation layer on the surface of the plated layer of the master die and the second exfoliation layer forming process that in advance of the second electroforming process an organic exfoliation layer on the surface of the normal concavities/convexities of the mother die, the exfoliations between the master die and the mother die and between the mother die and the stamper are smoothly performed. As a result of this, it is possible to avoid the occurrence of an accident that unexpectedly causes damage or flaw to the die.

Further, in each of these respective aspects of the invention, if the stamper is made to be the one that is used for molding of the lens sheets, each of the above-described modes of invention can be applied to reproducing a die that is used for molding the lens sheets.

Also, if it is arranged that the method of the invention be the method of reproducing a die that has the deposition film forming process that forms a deposition film on the

concavities/convexities pattern surface of the product and the electroforming process that manufactures the stamper equipped with a reverse concavities/convexities on the concavities/convexities pattern surface of the product, having formed thereon the deposition film, through the execution of electroforming, it is only necessary that the product with regard to that viewed from the standpoint of a lens sheet it has been confirmed whether the property thereof is good be used as the mother die. In addition, the electroforming that needs a long time is only executed once. Therefore, the dies the properties of that are the same can be reproduced with a short period of time.

Also, if the property check method of a master die has, in the reproducing process of a die that is equipped with the first electroforming process that manufactures a mother die equipped with a normal concavities/convexities pattern from a master die having formed in its surface a reverse concavities/convexities pattern through the electroforming and the second electroforming process that further manufactures a stamper equipped with a reverse concavities/convexities pattern from the mother die through electroforming, the plating process that plates the reverse concavities/convexities of the master die, the molding process that directly molds using the plated master die and the property check process that directly checks the property of the molded product, the following advantage can be obtained. Namely, conventionally, whether the master die is good was determined using the product that had been produced

using a stamper manufactured through the twice executed electroforming processs each of that usually takes a long time and performing resin-molding. However, in that property check method of a die, since the product is obtained from the master die by directly performing the resin-molding, it is possible to determine within a short period of time whether the master die is good.